CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the identification of the stress and strain parameters to be used in modelling the proposed fatigue model expressions. The two developed expressions and the process flow of the proposed model are explained. Details of the application of a genetic algorithm in the calibration of the proposed model equations and critical plane identification are presented. The validation procedure of the proposed model is described with the loading conditions, materials and details of FEA models being used and mesh convergence study is also presented.

3.2 FLOW CHART OF THE STUDY

The flow chart of the study is presented in Figure 3.1. This flow chart shows the flow of steps in the development and evaluation of the proposed model. Stress and strain parameters are identified to include in the proposed model from stress–strain history results. These parameters are able to capture the effects of proportionality of stress, mean stress effects and strain hardening. The selected stress–strain parameters are assembled in fatigue parameter expressions in the form of strain energy named as Model-1 and summation of terms named as Model-2, an expression to account the evolution of stresses and an expression to quantify the damage. A genetic algorithm based calibration method is developed to determine the value of coefficients and material constants based on previously published experimental fatigue life results. A comparison of prediction accuracy and ease of calibration between the proposed model Model-1 and Model-2 are performed. Performance study of the proposed fatigue model with the selected fatigue parameter expression is done against various material and loading conditions. Results are analyzed and findings of the study are concluded on the basis of the obtained results.

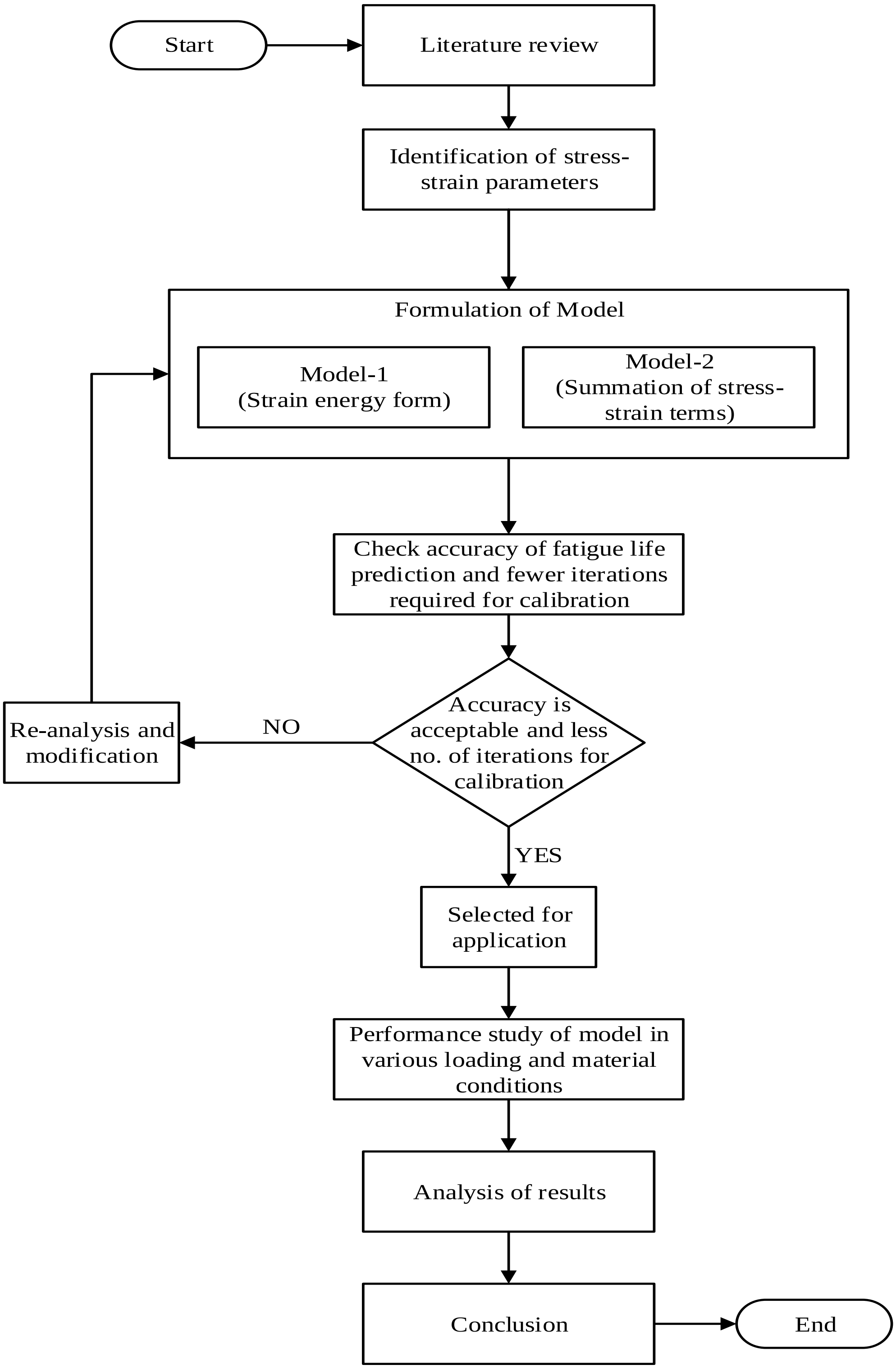

Figure 3.1: Flow chart of the study.

3.3 STRESS AND STRAIN PARAMETERS

From more than 50 years, researchers have put a great amount of effort into proposing new models to estimate fatigue life that can deal with various complex real-world scenarios, as reviewed in Chapter 2. But in the end it all comes down to the fact that the proposed expressions to determine equivalent stress / strain or fatigue parameters are combinations of certain stress and strain quantities, a fact also identified by (Socie and Marquis, 2000). A list of highlighted parameters is given in Table 3.1. The variables mentioned in Table 3.1 are those that have been most commonly used to establish the fatigue models studied in chapter 2. As mentioned by (Socie and Marquis, 2000; Ince, 2012), successful models have included features like being simple, efficient and applicable to various types of loading conditions, applicable in low and high cycle regimes, being able to include mean stress effect and able to handle non-proportional hardening effects, being physically correct from the continuum mechanics viewpoint, without any additional material coefficients, being load path dependent and able to determine failure planes and include tensile and shear failure modes. In their respective models, the stress / strain quantities identified in Table 3.1 define the mentioned features that are required for a model to able to be acknowledged as ready for real-world applications.

3.3.1 Selection of Stress and Strain Parameters

The first and most important requirement put forward for the proposed model is to keep the implementation procedure simple and easy to use. Thus the stress and strain quantities which are to be used in defining the proposed model should be easily determined. Keeping this in focus, stress–strain parameters are selected such that they can be directly calculated from the stress–strain tensor defining the state of stress and strain at a predetermined location. This avoids the extra calculation effort needed for secondary stress–strain quantities like 5D Euclidean stress, stress invariants, stress amplitudes derived from enclosing surface methods etc.